ORIGINAL RESEARCH

Medical Spending for the 2001 Anthrax Letter Attacks

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ABSTRACT

Introduction: This paper assesses the total medical costs associated with the US anthrax letter attacks of 2001. This information can be used to inform policies, which may help mitigate the potential economic impacts of similar bioterrorist attacks.

Methods: Journal publications and news reports were reviewed to establish the number of people who were exposed, were potentially exposed, received prophylactics, and became ill. Where available, cost data from the anthrax letter attacks were used. Where data were unavailable, high, low, and best cost estimates were developed from the broader literature to create a cost model and establish economic impacts.

Results: Medical spending totaled approximately $177 million.

Conclusions: The largest expenditures stemmed from self-initiated prophylaxis (worried well): people who sought prophylactic treatment without any indication that they had been exposed to anthrax letters. This highlights an area of focus for mitigating the economic impacts of future disasters. (*Disaster Med Public Health Preparedness*. 2019;13:539-546)

The anthrax letter attacks, commonly referred to by their US Federal Bureau of Investigation case name, Amerithrax, took place in the fall of 2001. Seven letters containing *Bacillus anthracis* (ie, anthrax) were mailed to media and political targets in the United States. This resulted in the first deployment of the US Strategic National Stockpile (SNS).[1] The subsequent policy and research response to these attacks has aimed to prevent future illness and loss of life. Despite high levels of research funding and prominence in a national discussion on terrorism, to our knowledge no complete accounting of the medical costs associated with these anthrax attacks currently exists. Understanding the medical costs of this event is essential for building future response policies.

Existing analyses investigate cost-effectiveness of countermeasures against future attacks,[2,3] the economic consequences of future attacks,[4] how (or if) the federal budgeting process changed in the wake of the terrorist events of 2001,[5,6] and public support for defense spending more generally.[7] Various frameworks and methods have been put forth to estimate the costs of terrorism,[8-11] but central to all these approaches is having a reasonable assessment of direct costs of actual terrorist events. Currently, no such estimate exists for the direct medical costs of the anthrax letter events, though 1 peer-reviewed article contains an estimate of only the decontamination costs for the anthrax letter attacks.[12]

Information relating to this terrorist attack is spread through disparate articles outlining the number of individuals who were ill, exposed, and potentially exposed; the process for epidemiological investigation; diagnosis; and medical treatments.[13–16] Belongia and Kieke et al. (2005) and M'ikanatha and Julian et al. (2005) surveyed physicians to estimate requests by nonexposed individuals for treatment, and Shaffer and Armstrong et al. (2003) tracked increases in purchased medications commonly used for anthrax prophylaxis during and after the attacks.[17–19]

In addition, various reports related to the medical response to the attacks are available from state public health departments as well as the Congressional Budget Office and the United States Postal Service (USPS). The US Government Accountability Office reviewed the USPS's response to the anthrax attacks and reported some of the hospital expenditures accrued by USPS.[20] The number of people infected and the recommended treatment or prophylaxis protocol was tracked and published by the US Center for Disease and Prevention and the Pennsylvania Department of Health and was later reported by the US General Accounting Office (GAO).[21-25] Additionally, the US Department of Health and Human Services released information regarding government drug purchases for the Strategic National Stockpile.[26] In this article, we synthesize existing information on the anthrax letter attacks into a cohesive estimate of the medical costs associated with those events. This direct cost estimate can then be used as an input into an input-output or other model of economic consequence.

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METHODS

Information regarding the medical impacts of the anthrax letter attacks was compiled from journal articles, public health alerts, and news reports. These sources provided detailed information on the number of people who became ill, as well as the number of casualties. Additionally, published data were found detailing the number of people who were potentially exposed (for whom a full course of prophylactic drugs was recommended), as well as the number of people thought to have been potentially exposed (for whom short courses of prophylactics were recommended, pending confirmation of whether or not they had been in areas of potential exposure).

Data on treatment costs for these individuals were not found. Instead, best estimate treatment costs for the ill were compiled using published treatment procedures. For inhalation anthrax, this involved data on the only nonterrorism-related victim of inhalation anthrax in the United States since 1976, as well as published cost estimates for those particular forms of treatment. A similar approach was used to estimate treatment costs for cutaneous anthrax infection.

Prophylactic treatment costs were estimated using the known number of people receiving a particular course of drugs. The type of drug used in treatment was estimated by extrapolating available data on a small sample size to the entire affected population. This information was then combined with drug costs ascertained through US federal contracts. Since the objective of this paper is to estimate the cost of the anthrax letter attacks when they occurred, all estimates are converted to 2001 dollars.

Data on actual medical costs incurred by the federal government and the USPS were not available. The only existing information on medical costs for USPS was a $618 000 expenditure reported in a GAO report. This was only a partial cost for hospital visits made by employees from the Trenton Processing and Distribution Center (PDC).[20]

Various published analyses also demonstrate that there was a demand for prophylactic drugs from people who were not exposed to anthrax spores at all, commonly referred to as the "worried well." No precise data were found on the costs incurred by the worried well, so cost estimates were formed based on published reports of increased drug prescriptions filled, which are otherwise unaccounted for.

Finally, the loss of life due to these anthrax releases was assigned a dollar value using statistical value of a life methods.

For all sections, unless otherwise mentioned, dollar amounts are quoted in 2001 real dollars. Where the actual cost data are not available, we generate high, low, and best estimates in several cost categories to create a model and establish economic impacts. For some cost categories, only a best estimate is given. These are categories for which actual cost data are available or where the magnitude of the cost is dwarfed by other expenditure categories. Table 1 displays the key estimates used in this analysis and their sources.

Effort was made to provide the most precise accounting possible, but the implications for policy-making can be seen in the factors difference between varying cost categories.

Treatment Costs

The only concrete data available for treatment costs for people exposed to anthrax spores comes from a GAO report and included partial costs of Trenton PDC employee hospital visits.[20] When anthrax was suspected at the USPS Trenton PDC, a nearby hospital treated some potentially affected USPS employees. USPS paid a total of $618 000, however, this cost included an unknown fraction of potentially exposed employees.[20] Given that neither the number of individuals nor the treatment type is known, it is necessary to generate cost estimates.

Confirmed Cases and Exposure Categories

There were 23 known cases of anthrax infection caused by the anthrax letter attacks; 12 cases of cutaneous anthrax (spores entering through the skin) and 11 cases of inhalation anthrax.[14,23] Five of the inhalation infections resulted in death.[14] Nine USPS employees were infected, along with 3 other mail handlers, 1 at a government mail processor and 2 from media company mail rooms.[14] All but 3 of the remaining victims were exposed through a workplace that was either a direct target of an anthrax letter or which handled anthrax-laden letters.[14] For example, one cutaneous case occurred months later at a Texas laboratory that conducted testing for the Amerithrax case.[23] The route of exposure is not clear in all cases. One woman contracted inhalation anthrax, likely at home, simply through cross-contaminated mail.[14]

A detailed timeline of the health response to the anthrax attacks was compiled by the GAO which tracks each exposure case, as well as the prophylaxis protocols employed, which varied from state to state.[25]

Treatment of confirmed cases of infection generally involved hospitalization, usually after an initial doctor visit. Both confirmed anthrax infection and suspected anthrax exposure requires drug treatment with one or more antimicrobial drugs. During the anthrax letter attacks, ciprofloxacin was initially the most widely distributed drug, being the only one approved for anthrax prophylaxis at time.[25] Doxycycline was approved for postexposure prophylaxis on October 18, two weeks after the first confirmed case of inhalation anthrax was announced.[25] Amoxicillin was also approved for postexposure prophylaxis, but its use was generally reserved for children and pregnant and lactating women.[27] Few children

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TABLE 1

Key Parameters Used in Cost Estimates

		Best Estimate	Low Estimate	High Estimate	Source
Fatalities	Fatalities	5			Jernigan et al.[14] 2002
	Statistical value of life, $ million	5.3	1.9	11.3	Dockins et al.[38] 2004 Mrozek and Taylor[39] 2002 Viscusi and Aldy[40] 2003
Illness	Inhalation cases	11			Jernigan et al.[14] 2002
	Cutaneous cases	12			Jernigan et al.[14] 2002
	Length of hospitalization, days	34			Walsh et al.[28] 2007
	Cost of hospitalization, $/day	3000			Halpern and Pastores[29] 2007
	Prescriptions, short course	21 700			Shaffer et al.[19] 2003
CDC prophylaxis (preventive treatment from Strategic National Stockpile)	Prescriptions, full course	10 300			Jernigan et al.[14] 2002
	Duration, short course, days	10			CDC[22] 2001
	Duration, full course, days	60			Greene et al.[13] 2002
	Doses per day	2			PA Dept. of Health[21] 2001
	Cost of ciprofloxacin, $/pill	1.79			DeSalvo and Block[27] 2002
	Cost of doxycycline, $/pill	0.1			DeSalvo and Block[27] 2002
Self-initiated prophylaxis (worried well)	Additional ciprofloxacin prescriptions	160 000	160 000	160 000	Shaffer et al.[28] 2003 Belongia et al.[17] 2005
	Additional doxycycline prescriptions	96,000	0	216 000	
	Additional medical visits	1 024 000	0	1 504 000	Shaffer et al.[28] 2003 Belongia et al.[17] 2005 M'ikanatha et al.[18] 2005
	Cost of ciprofloxacin ($/pill)	4.29			DeSalvo and Block[27] 2002
	Cost of doxycycline ($/pill)	0.41			DeSalvo and Block[27] 2002
	Cost of medical visit, $	59.40			Halpern and Pastores[29] 2007

are mentioned in literature, and less than 1% of those receiving long course prophylaxis were pregnant, so distribution of amoxicillin is considered negligible for these estimates. Treatment with both of the other drugs requires 2 pills per day.[22]

Costs for treating cutaneous and inhalation anthrax are very different. Inhalation anthrax requires an extended stay in a critical care ward and can include use of a mechanical respirator. In 2006, a man in the United States was diagnosed with the first naturally occurring case of inhalation anthrax since 1976; his treatment involved a 34-day hospital stay.[28] Halpern et al. estimate the per-day cost of critical care to be about $3000 per day in 2001 dollars.[29] Using the average cost per day of a hospital stay allows us to estimate a total treatment cost of about $102 000 for this case of inhalation anthrax in 2001 dollars.

Cutaneous anthrax can be treated with oral antibiotics and does not usually require hospitalization. Treatment is a 60-day course of medication, similar to a full course of prophylaxis, which could cost between $12 and $215 (as outlined in the following section). This would be accompanied by a corresponding doctor's visit.

However, simply estimating this as the cost of a doctor's visit and medication in 2001 dollars would likely neglect potential costs of confirmation visits with specialists and additional precautions taken due to the possibility of contamination. To encompass these costs, we assume that a case of cutaneous anthrax would cost the same as single day in critical care, or $3000. This is 2 orders of magnitude less than the cost of treating inhalation anthrax, which mitigates any unknowns in its cost estimate.

Among those infected, there were 12 cutaneous and 11 inhalation cases. When these costs are applied to each of the anthrax victims, this leads to a best estimate total treatment cost of $1.16 million.

For our low estimate, we draw on the cost estimation done by Fowler and Sanders et al., who report a likely cost of about $29 000 to treat a severe case of inhalation anthrax.[3] Attributing this cost to all victims regardless of infection type leads to our low estimate of $0.67 million. For our high estimate, we assume that actual treatment costs were twice that which we found based simply on hospital stay duration and type of treatment. This cost doubling assumes an elevated treatment cost in the face of an actual emergency when extra

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precautions may be taken without regard to cost efficiency. This gives a high estimate of $2.32 million.

Full Course of Prophylaxis Recommended

In addition to individuals eventually confirmed to have anthrax, anyone exposed to or potentially exposed to an aerosolization of anthrax spores was instructed to take a full 60-day course of prophylaxis (FCP).[13] Based on data and experience at the time, it was considered unlikely that inhalation anthrax would occur more than 60 days after initial exposure to the spores.[21] Current literature suggests that inhalation anthrax has an incubation period of between 4 and 10 days.[30] At each site for which information was found, postexposure prophylaxis was administered within 4 days of confirmed anthrax identification and as quickly as the same day.[25]

Prophylaxis was not generally recommended as a preventative measure against cutaneous anthrax.[13] Cutaneous infection is slower acting and easier to treat than inhalation infection and is rarely life-threatening.

FCP was recommended for all employees who worked at highly contaminated sites, as well as anyone who had visited these sites for more than 1 hour. These sites include large USPS processing centers as well as certain Capitol Hill buildings. In total, a full 60-day course of prophylaxis was recommended for approximately 10 300 people.[14]

Drugs were provided from the Strategic National Stockpile free of charge and were generally distributed in 1, 2, or 3 intervals. In six US cities, the distribution ratio of antibiotic prophylaxis was 94% ciprofloxacin and 6% doxycycline in the first 10 days of drug distribution. However, by the 30th day, the percentages had shifted to 26% ciprofloxacin and 74% doxycycline.[31] When drugs were given out over several intervals, ciprofloxacin was often given out at preliminary distribution clinics but "the recommended antibiotic for postexposure prophylaxis was changed to doxycycline for the 2 follow-up clinics, after testing showed the *B. anthracis* isolates were susceptible to doxycycline."[13] This corresponds to the way in which ciprofloxacin in the SNS was meant to be used.[26]

In general, the number of people collecting the drugs recommended to them waned, depending largely on the cohort. The heavily contaminated Trenton Processing and Distribution Center clinics distributed drugs in 3 phases, giving out 10, 25, and then a further 25 days worth of drugs at a time.[13] Clinic attendance by the 1069 USPS employees at Trenton went from 97% at the initial clinic to 93% and then 83% at the subsequent clinics.[13] At the same facility, distribution to the 324 people who had merely visited the site went from 90% initially to 64%.[13] We extrapolate adherence to other contaminated sites using adherence rates of 97%, 93%, and 83% to represent best-case adherence rates.

Since distribution was often stepwise (done in 5- to 30-day chunks), we assume a ciprofloxacin to doxycycline ratio of 94% to 6% for the first 10 days of prophylaxis and a ratio of 26% to 74% after that as suggested by the distribution ratio on the 30th day of distribution.[31] Using these distributions, we can calculate the total doses of each drug distributed. This totals to about 423 000 individual doses of ciprofloxacin and 680 000 doses of doxycycline.

The ciprofloxacin distributed during the anthrax incident was purchased in 2000 when the US government bought 240 million pills for $1.79 per pill, while the government purchases the generic drug doxycycline at a cost of $0.10 per pill.[27] This amounts to a cost of $757 000 for ciprofloxacin and $68 000 for doxycycline. Only a best estimate is provided here because adequate data are available for these costs and because expenditures in this category are relatively small compared to other expenditures. For similar reasons, no conversion from year 2000 real dollars to 2001 real dollars is made.

Short Course of Prophylaxis Recommended

During the initial stages of the anthrax letter attacks, prophylaxis protocol was not standardized. In many cases a short course of prophylaxis (SCP) was provided to workers at potentially contaminated sites pending further investigation and lab tests. Protocols for drug distribution varied from site to site. At some sites drugs were distributed before sampling began and at others they were only distributed after an environmental sample came back positive.[32] On Capitol Hill, for example, a SCP was given to any member of the general public who requested it.[31,33] Most of these drug courses were stopped when inhalation anthrax was eliminated as a possible threat. In total, a SCP was recommended for approximately 21 700 individuals.[14]

Treatment for these 21 700 individuals involved 2 doses per day of either ciprofloxacin or doxycycline. The exact duration of prophylaxis prescribed for every individual is unknown. However, at many facilities suspected to be contaminated, employees were given a 10-day course of drugs pending further investigation or decision-making.[24] We assume that this was common practice and use 10 days as a baseline. To arrive at a cost estimate, we use the same ratio of drug distribution and costs as for the initial distribution of drugs for the FCP (94% ciprofloxacin, 6% doxycycline).

A 10-day treatment for all SCP results in 408 000 doses of ciprofloxacin at a cost of $730 000 and 26 000 doses of doxycycline at a cost of $3 000. Again, only a single cost estimate is provided since these costs are small in comparison to other cost categories.

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Self-initiated Prophylaxis: The Worried Well

We define the self-initiated prophylaxis group as those who feared illness or exposure and who sought prophylaxis through their own private doctors without the recommendation of any governing or advising body. This group is typically referred to in the terrorism literature as the worried well.[34] This designation can be problematic in the context of the anthrax letter attacks, as seeking self-protection from anthrax was not necessarily illogical, since at least 1 person was exposed through cross-contaminated mail.[14,35]

In addition, the anthrax event occurred near to 9/11. The public was understandably scared and risk communication following both events focused on personal preparedness (for example, suggesting that individuals purchase plastic sheeting and duct tape).[36]

For this category, we try to assess the number of people who preemptively bought some course of antibiotics without necessarily commencing treatment. They are measured by an otherwise unaccounted-for rise in purchased prescriptions for prophylactic drugs following the anthrax attacks. We do not include individuals who purchased other preventative measures such as plastic gloves or sheeting, since these are not medical costs.

The demand for prophylactic ciprofloxacin and doxycycline went up across the country, and spiked especially high in those regions specifically affected by the anthrax attacks.[17,18] Compared to the same months in 2000, an estimated 160 000 more ciprofloxacin and 96 000 more doxycycline prescriptions were filled in October 2001, and an estimated 120 000 more doxycycline prescriptions were filled in November 2001, when doxycycline became the treatment of choice for anthrax treatment.[13,19] This difference is striking because the overall prescription rate between July and December for these 2 drugs was greater in 2000 than in 2001, meaning that the rate of prescriptions was trending downward if October and November are excluded. Thus, much of the increase in ciprofloxacin and doxycycline for these months is likely due to the worried well.[19]

For our best estimate, we assume that increases in ciprofloxacin and doxycycline prescriptions in only October 2001 are due to the anthrax letter attacks. This is an increase of 256 000 prescriptions filled. For our high estimate, we assume that doxycycline prescriptions in November 2001 were also due to self-initiated prophylaxis, resulting in 376 000 prescriptions.[19] For our low estimate, we assume that only the additional 160 000 ciprofloxacin prescriptions in October 2001 represent self-initiated prophylaxis.

Using best estimates, the ratio of individuals who self-initiated prophylaxis to potentially exposed individuals for whom a FCP was recommended is 256 000 to 10 300, roughly 25:1. This estimated ratio is lower than the ratio estimate for the Tokyo Sarin attack, where "the ratio of those who sought [immediate] medical care to those who required immediate medical care was approximately 450:1."[37]

Generating additional prescriptions for ciprofloxacin and doxycycline may have had a hidden cost of additional doctor's appointments. A survey conducted in late 2001 and early 2002 assessed the demand for prophylactic drugs as well as doctors' responses to the demand.[18] The authors report that approximately 25% of doctors who received requests for prophylactic prescriptions granted them to at least some patients.[18]

This suggests that each prescription for prophylaxis may represent not one but four additional doctors' visits, since only 1 in 4 doctors reported prescribing prophylaxis. Each doctor's visit is assigned a cost of $59.40, corresponding to the average cost of a visit to a general practitioner and adjusting to 2001 dollars.[29]

The cost of prophylactic drugs is much higher for the private consumer than for the government. When bought privately, ciprofloxacin sells for $4.29 per dose or $515 for a 60-day course of drugs.[27] Similarly, doxycycline purchased at the consumer level is $0.41 per dose or $49 per full course.[27]

For our best estimate, we assume each of the 160 000 additional ciprofloxacin and 96 000 additional doxycycline prescriptions for October 2001 were purchased for $4.29 and $0.41, and that 4 doctor's visits were generated for each additional prescription. This results in a best estimate of $148.0 million. This breaks down to $82.4 million for ciprofloxacin, $4.7 million for doxycycline, and up to $60.8 million for visits to the doctor. For our high estimate, we include the increase in November prescriptions of doxycycline and again assume 4 doctor's visits were generated for each additional prescription, resulting in $182.5 million. For our low estimate, we include only October ciprofloxacin prescriptions and assume that these were obtained during routine doctor's visits, resulting in an estimate of $82.4 million.

Loss of Life

The statistical value of a life (SVL) is a common quantity used in policy decision-making, theoretically allowing limited resources to be optimally allocated while providing a floor below which life-saving measures should be implemented and a ceiling above which these measures are generally regarded as too costly. SVL is typically calculated using willingness to pay or willingness to accept data, based either on survey responses or salary information for occupations with well-understood risk. The dollar value used varies between agencies, and is generally considered within an order of magnitude, rather than a strict singular value. Based on an extensive review of the literature, US Environmental Protection Agency (EPA) uses a SVL of $5.5 million 2003 dollars.[38] Two additional

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studies span the high and low ranges of SVL.[38] These are by Viscusi and Aldy, who estimate a range of $5.5 to $7.6 million with a best estimate of $6 million, and Mrozek and Taylor, who estimate a range of $1.35 million to $11.7 million with a best estimate of $2 million.[39,40]

We base our best estimate for the statistical value of a life on the revised EPA SVL of $5.3 million (adjusted to 2001 dollars). For our low and high estimates, we used the work of Mrozek and Taylor, choosing values of $1.9 million and $11.3 million (both adjusted to 2001 dollars), respectively. These amounts are then applied to the 5 victims who lost their lives in these attacks.

Table 1 summarizes the key parameters used to develop each cost estimate.

DISCUSSION AND RESULTS

The total medical costs associated with the anthrax letter attacks are presented in Table 2. Where possible, we provide upper and lower bounds on the costs as well as a best estimate. This was avoided only where information was sufficient for a confident estimate or when the best estimate values were small enough to make upper and lower bounds insignificant.

Table 2 summarizes each cost estimate.

Directly summing the costs shown in Table 2 results in a high estimate of $247.2 million, a best estimate of $178.5 million, and a low estimate of $132.7 million.

From a policy prospective, there are several noteworthy observations to make. One is that the amount of money spent by the worried well on prophylaxis is more than 2 orders of magnitude larger than the amount spent on prophylaxis for those who were legitimately exposed to anthrax. This may warrant further investigation and indicates that better risk communication with the public may be helpful when dealing with events of this nature. Additionally, the anthrax letter attacks events were a success story in terms of switching to a medically effective and cost-effective drug. While initial prophylaxis efforts used ciprofloxacin, clinics quickly responded to medical communications on the efficacy of doxycycline and adopted doxycycline in later rounds of prophylaxis. However, this may have been offset by a later policy decision to purchase more ciprofloxacin.

TABLE 2

Medical Costs

	High Estimate	Best Estimate	Low Estimate
	$ million		
Treatment of confirmed cases	2.3	1.2	0.7
Loss of life	56.5	26.5	9.5
Individuals exposed (full course of prophylaxis)	0.8	0.8	0.8
Individuals exposed (short course of prophylaxis)	0.7	0.7	0.7
Self-initiated prophylaxis	182.5	148.0	82.4
Total costs	**242.8**	**177.2**	**94.1**

The total number of antimicrobial pills distributed from the SNS was approximately 1.5 million (about 55% of which was ciprofloxacin). Following the terrorist events of 2001, the US Department of Health and Human Services purchased 100 million pills of ciprofloxacin, nearly 2 orders of magnitude larger than the number used during the anthrax letter attacks.[26] This may be noteworthy considering the disparity in costs between ciprofloxacin at $0.95 per pill and doxycycline, an equally effective antimicrobial drug which costs only $0.10 per pill. There are also concerns regarding the rise of antibiotic resistant bacteria in areas where large portions of the population are simultaneously taking long courses of a single antibiotic.

Supplying the SNS is clearly a complex multiobjective decision problem and designed for extreme scenarios.[41,42] The drugs contained in the SNS can be used to combat communicable disease as well as bioterror events, and reducing fatalities may have more to do with the location and distribution of prophylactic treatment at local levels rather than the size of the overall national SNS.[41] Nevertheless, it is comforting that the most fatal bioterror attack in US history required less than 0.5% of the Strategic National Stockpile for ciprofloxacin.

CONCLUSION

Our analysis indicates that the major medical costs associated with the anthrax letter attacks stemmed from individuals who sought treatment on their own, while loss of life was the next highest outlay. In total, 1.5 million doses of prophylactic drugs were distributed to over 32 000 people. This analysis suggests that the value of life lost was 10 times higher than the cost of distributed prophylaxis. While cost considerations naturally carry less weight than preserving life, this finding emphasizes the relatively low cost associated with preventative prophylaxis. Costs associated with the self-initiated prophylaxis account for about $148 million, or more than 80% of total costs. This suggests that individuals' responses plays a large role in the total cost of bioterror events, and that managing risk communication is key to keeping the costs of such an event low.

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